GLYCEMIC AND LIPEMIC RESPONSES OF SELECTED SPIRULINA-SUPPLEMENTED RICE-BASED RECIPES IN NORMAL SUBJECTS

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ABSTRACT

The glycemic index (Gl) was determined in 30 healthy subjects who were fed 50g carbohydrate portions of five rice based recipes namely, plain rice, a combination of rice - legume (green peas), a combination of rice - dal (green gram dal and red gram dal) and vegetable pulao (rice and vegetables) with curd. All the recipes were supplemented with 2.5 g spray dried spirulina powder. In addition to the Gl, triglyceride (TG) responses of these foods were also determined. All the foods produced significantly lower blood glucose response two hours postprandially as compared with blood glucose responses to a 50g glucose load for the same group. Also there was a marked reduction in the triglyceride levels.

KEY WORDS: DIABETES MELLITUS; SPIRULINA SUPPLEMENTED FOODS.

INTRODUCTION

One of the most prevalent metabolic disorders of both developed and developing countries is diabetes mellitus. All patients with diabetes mellitus need to follow a proper dietary regimen to control their disease. A low risk diet, suitable for this purpose consists of a high proportion of complex carbohydrate, adequate protein, low fat content, enriched with minerals and vitamins and has a low glycemic index (Gl), Spirulina is a good food source which contains not only good quality protein, but other essential nutrients and therefore can be used as therapeutic supplement in the management of various nutritional and metabolic disorders. Hence, the present study was planned to determine the Gl of five rice based recipes supplemented with spirulina at 2.5g level. Hyperlipidemia is a common complication associated with diabetes and enhances its secondary complications. Therefore, foods recommended in diabetics should also have low lipemic responses. Thus, in the present study, the triglyceride (TG) responses of the test recipes was also monitored.

METHODS AND MATERIALS

Thirty healthy volunteers residing in Vadodara, were enrolled for the study. The clinical profile of the subjects is given in Table 1. On the first visit, an oral glucose tolerance test (GTT) was done for all the subjects using 50g glucose. Blood glucose was determined by the O - toludine method [1] in fasting and postprandial (1 and 2-hour.) samples; TG was determined in fasting and 2-hour postprandial blood samples using enzokit [2]. The subjects were divided into five groups comprising of six subjects each. During the second visit (within 1 week), the subjects were given a test food containing 50g carbohydrate which was consumed over 10-12 minutes. The composition of the foods, as determined by food table [3] is given in table 2. Again, blood glucose and TGs were determined for the different groups, fed different foods. Blood glucose response curves for both GTT and the test recipe were plotted and GI was calculated using the method described by Jenkins et al [4]. This was done by determining the ratio of the areas under the glucose response curve for the food, compared with that of GTT. The TG response was calculated by finding the percent rise/fall in mean TG value over mean fasting value for six subjects.

The five foods given were : rice alone (R1); rice with

Table 1 : Clinical profile of healthy subjects (mean ± SD)

Variable	Mean ± SD
Number of subjects	30
Males	3
Females	27
Age (years)	22.0 ± 1.8
Height (m)	1.6 ± 0.07
Weight (kg)	48.8 ± 7.8
Body Mass Index (kg/m^2)	20.0 ± 3.0
Waist (cm)	64.2 ±8.3
Hip (cm)	91.7 ± 6.1
Waist / Hip ratio	0.69 ± 0.06

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Table 2 : Nutrient composition of recipes

Recipes	Ingredients	Raw WT (g)	Energy (Kcal)	CHO (g)	Protein (g)	Fat (g)	Crude Fibre (g)
Rice alone	Rice	64	221	50	4.4	0.3	0.13
(R1)	Oil	5.0	45	--	--	5.0	--
	Spirulina	2.5	11	0.4	1.8	0.17	0.02
			277	**50.4**	**6.2**	**5.47**	**0.15**
Rice with	Rice	45	155	35	3.1	0.2	0.09
green	Green gram dal	25	87	15	6.1	0.3	0.2
gram dal	Oil	5	45	--	--	5.0	--
(R2)	Spirulina	2.5	11	0.4	1.8	0.17	0.02
			298	**50.4**	**11.0**	**5.67**	**0.31**
Rice with	Rice	45	155	35	3.1	0.2	0.09
red	Red gram dal	26	87	15	5.8	0.4	0.39
gram dal	Oil	5	45	--	--	5	--
(R3)	Spirulina	2.5	11	0.4	1.8	0.17	0.02
			298	**50.4**	**10.7**	**5.77**	**0.5**
Rice with	Rice	45	155	35	3.1	0.2	0.09
peas	Peas green	27	85	15	5.3	0.3	1.21
(R4)	Oil	5	45	--	--	5.0	--
	Spirulina	2.5	11	0.4	1.8	0.17	0.02
			296	**50.4**	**10.12**	**5.67**	**1.32**
Vegetable	Rice	50	173	39.1	3.1	0.25	0.10
pulao with	Tomato	20	4	0.72	5.8	0.04	0.16
curd	Peas	20	19	3.18	--	0.02	0.80
(R5)	Cauliflower	20	6	0.80	1.77	0.08	0.24
	Potato	10	19	4.52	0.32	0.02	0.08
	Onion	20	10	2.22	0.24	0.02	0.12
	Carrot	20	10	2.12	0.18	0.04	0.24
	Curd	50	12	0.60	0.62	0.80	--
	Oil	5	45	--	--	5.0	--
	Spirulina	2.5	11	0.41	1.77	0.17	0.02
			309	**53.67**	**8.67**	**6.44**	**1.76**

green gram dal (R2); rice with red gram dal(R3); rice with peas green (r4); vegetable pulao with curd (R5); each supplemented with spirulina powder at 2.5 g level. The foods were pressure cooked at 15lb pressure for 15 minutes using 385 ml of water. Analysis of variance (ANOVA) was used to compare Gl values among the test recipes. Mean percent rise/fall in serum TG from fasting to two hour postprandial levels was calculated for each of the test recipe fed.

RESULTS

The Gl values obtained for the foods are given in Table 3. Rice in combination with red gram dal (R3) and vegetable pulao with curd (R5) were significantly different from rice alone (R1). Table 4 presents the mean value ± SD of blood glucose to a 50g glucose load as well as the respective foods. This has also

Table 3 : Glycemic index of Spirulina supplemented recipes (mean ± SD)

	Recipe index	Glycemic	F Value
R1	Rice	58.9 ± 4.0**	
R2	Rice + green gram dal	50.9 ± 8.0	
R3	Rice + red gram dal	37.9 ± 11.7**	3.54*
R4	Rice + peas	47.6 ± 11.0	
R5	vegetable Pulao	45.5 ± 8.4**	

F Value : * significant at $p < 0.05$
** significant at $p < 0.01$ when R1 was compared with R3 and R5.

Table 4 : Blood glucose responses of GTT and Spirulina supplemented recipes (Mean ±SD, mmol/L)

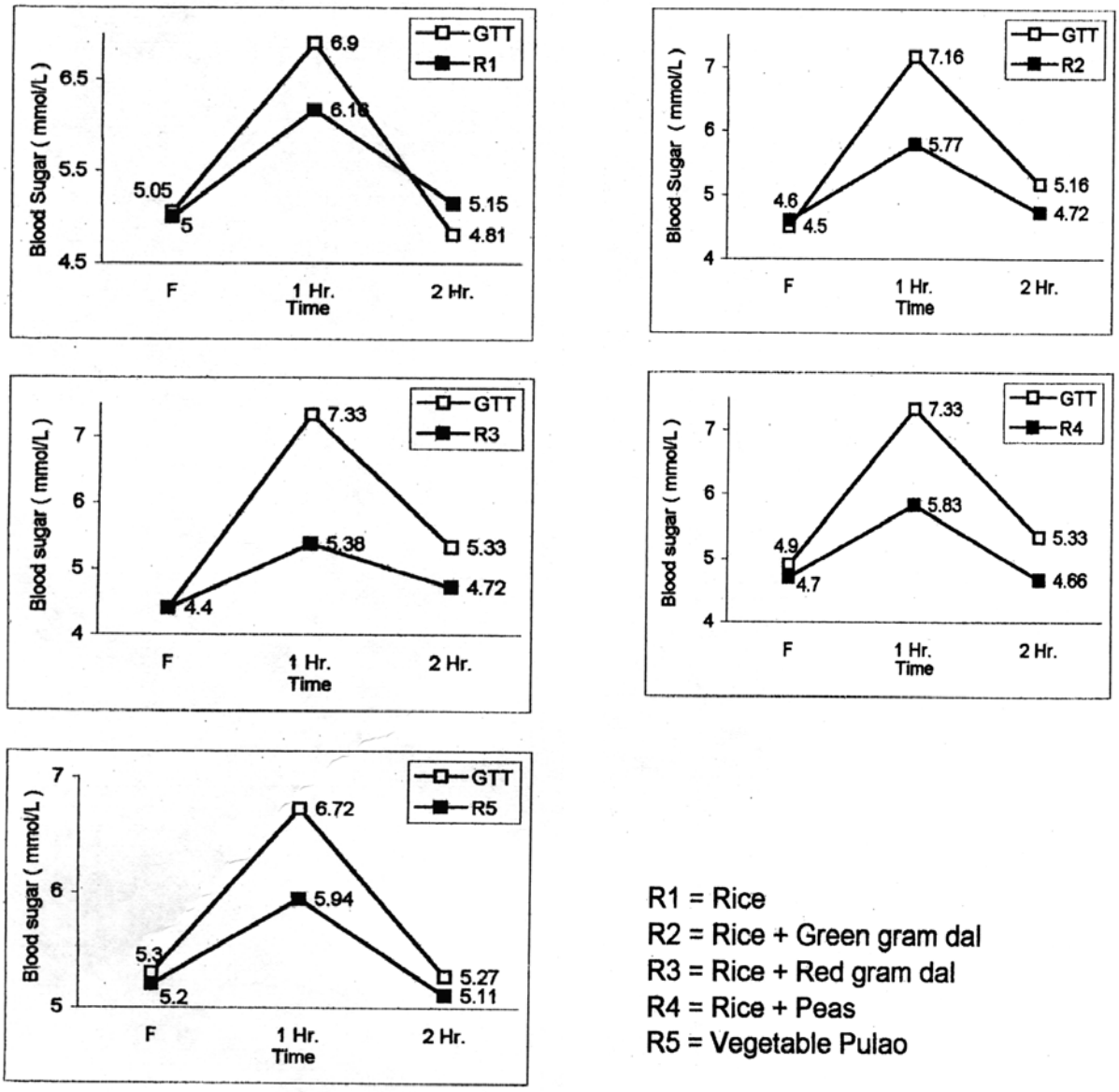
-CHO source	Fasting Responses	Postprandial 1 hour	Responses 2 hour
Glucose	5.0 ± 0.003	6.9 ± 1.46	4.81 ± 0.57
R1	5.0 ± 0.65	6.16 ± 1.33	5.15 ± 0.72
Glucose	4.5 ± 0.36	7.16 ± 0.93	5.16 ± 1.02
R2	4.6 ± 0.33	5.77 ± 0.45	4.72 ± 0.56
Glucose	4.4 ± 0.30	7.33 ± 0.81	5.33 ± 0.82
R3	4.4 ±0.61	5.38 ± 0.73	4.72 ± 0.81
Glucose	4.9 ± 0.73	7.33 ± 0.79	5.33 ± 0.51
R4	4.7 ± 1.05	5.83 ± 0.73	4.66 ± 0.55
Glucose	5.3 ± 0.53	6.72 ± 0.96	5.27 ± 1.06
R5	5.2 ± 1.43	5.94 ± 0.94	5.11 ± 0.83

been graphically represented in Fig. 1. One hour postprandially there were significantly lower responses to R2, R3, and R4 than to a 50g glucose load for the same group and the mean value of the remaining two foods were not significantly different from the response to glucose. Table 5 presents the 2 hour postprandial TG response.

DISCUSSION

The concept of Gl of various foods has emerged as a boon to dietary therapy for diabetes mellitus, indicating the beneficial aspect of foods consumed both individually and as mixed meals,. Studies by Jenkins et al (5,6), Mani et al (7, 8, 9), Thorne *et al*

Fig 1: Blood glucose responses of GTT and Spirulina supplemented recipes (mean ± SD, mmol/L)



R1 = Rice
R2 = Rice + Green gram dal
R3 = Rice + Red gram dal
R4 = Rice + Peas
R5 = Vegetable Pulao

Table 5: Triglyceride responses of Spirulina supplement recipes (mean SD, ± mmol/L)

-CHO source	Fasting rsponse	Postprandial 2 hour	% rise/fall over fasting
Glucose	1.19 ± 0.61	1.08 ± 0.71	
R1	1.19 ± 0.63	1.08 ± 0.74	- 9
Glucose	0.78 ± 0.16	0.63 ± 0.18	
R2	0.89 ± 0.15	0.84 ± 0.16	- 5
Glucose	0.88 ± 0.15	0.79 ± 0.28	
R3	1.14 ± 0.19	1.10 ± 0.21	- 4
Glucose	0.86 ± 0.2	0.79 ± 0.24	
R4	1.07 ± 0.2	0.99 ± 0.16	- 8
Glucose	0.82 ± 0.31	0.72 ± 0.34	
R5	0.94 ± 0.41	5.96 ± 0.45	2

(10), O'Dea et al(11) and several others have shown that foods providing equicabohydrate portions, elicit different postprandial glycemic responses. In view of the various factors affecting the Gl, such as the nature of the source of starch, physical from of the food, method of cooking/processing, starch - nutrients, it becomes essential that many more foods and meals should be screened for their glycemic responses and their suitability for a diabetic diet. several studies have determined the Gl values for some foods consumed in India (7, 8, 9, 12). In this study, we have determined the Gl for the most commonly used single foods and mixed meals, incorporated with 2.5 g of sprayed dried spirulina powder each, by determining glucose responses at two time intervals.

Starch granules in cereal grains are structurally different from those in leguminous seeds. This affects particle size and surface area, resulting in altered digestion by hydrolytic enzymes. Rice starch granules are small and angular, probably resulting in a higher Gl, as observed from the Gl of the foods tested by Mani et al (7).

Legumes and dals have a higher amylose content (30-40%), which is more resistant to cooking and digestion than amylopectin. Rice has a higher amylopectin content, which may partially explain the higher Gl of rice.

Protein in the diet has been shown to stimulate insulin secretion, thereby, lowering the postprandial glucose concentration (13). The protein content in the five recipes fluctuated in the range of 6.2 to 11.0g. Thus, the high protein content of dals and pulses in R2, R3, and R4 could be the contributing factor for lowering the Gl.

Dietary fibre due to its viscous nature, inhibits starch digestion and/or digestion. Fibre and galactomannans that are present in legumes and dals are more viscous than those found in cereals (14). In the present study, recipes with increasing amounts of fibre (R3, R4, R5) have elicited a lower Gl than the other recipes (R1, R2). This has also been supported by a study carried out by Mani et al, (7).
Besides the nutritional and non nutritional factors affecting the glycemic response, efforts are being made to look for new food sources which when added to any meal (either mixed or singly) bring down the starch digestibility appreciably. In this regard, spray dried spirulina powder (the blue green algae), was added to the above five recipes. It has been observed that addition of 2.5 g spirulina powder brought about lower glycemic response in diabetic individuals, indicating that spirulina has got some factor which helps to lower the postprandial rise in glucose.

Rice has been extensively studied by various investigators (7, 15, 16, 17) in both normal and diabetic subjects and it has been concluded that rice should be classified as high Gl food. rice alone has given a Gl of 77% (18) and 81% (16) in non diabetics. The Gl of rice alone in NIDDM patients was obtained as 74 ± 8% (7). From the literature available and from the results of the present study, it can be concluded that, addition of 2.5 g of spray dried spirulina powder to rice resulted in a low Gl of 59%.

In a study carried out by Mani at al (7), Gl for six rice based recipes was determined in NIDDM subjects. From these, four of the recipes were selected for the present study, but tested on normal individuals. The Gl of these recipes with and without spirulina as tested in normal subjects and diabetics respectively, are as given in Table 6.

Table 6 : Gl% of rice based recipes with and without spirulina (7).

Name of Recipe	Without Spirulina (IDDM)	With spirulina (NORMAL)
Rice alone	80 ± 14	58.9 ± 4.0
Rice + Green gram dal	62 ± 8	50.1 ± 8.0
Rice + Red gram dal	64 ± 6	37.9 ± 11.7
Rice + peas	74 ± 8	41.6 ± 14.5

The nutrient composition of 2.5 g of spray dried spirulina powder is given in Table 7. Spirulina is a

rich source of proteins and provides good quality aminoacids. It has been well established that both protein and amino acid ingestion stimulate insulin secretion and thus may affect the postprandial glucose concentration (19). It could be speculated that addition of 2.5 g if spirulina which is rich in protein may bring in the insulin peak earlier in the recipes with spirulina and this could be one of the possible mechanisms by which a lowered glycemic response is seen in recipes supplemented with spirulina. Since, in the present study, the GI has been determined in healthy individuals, it may be suggested that these spirulina supplemented recipes will bring about a lower glycemic index in diabetics also.

Table 7: Nutrient composition of 2.5 g spray dried Spirulina powder.

Nutrients	Amount (g)
Carbohydrate	0.41
Protein	1.77
Fat	0.17
Fibre	0.02

Since diabetes mellitus causes not only abnormal carbohydrate metabolism but also alters lipid metabolism, especially cholesterol and TG (20, 21), we also determined TG responses to the foods. In this study, the highest percentage fall from fasting to two hour post recipe was found for R1 closely followed by R4. It has been reported that low Gl diets brought about a 20% reduction in TG levels in patients with hypertriglyceridemia (18).

The lipemic response of the selected four recipes with and without spirulina as tested in normal subjects is given in Table 8.

Table 8 : Lipemic responses to various foods with or without spirulina

Recipes	GI%	Rise/fall in serum TG
	without spirulina	with spirulina
Rice alone	40	- 9
Rice + Green gram dal	86	- 5
Rice + Red gram dal	39	- 4
Rice + Peas	20	- 8

Thus, from the present study, it is clear that spirulina has a definite role in the lowering of the glucose and TG levels. Therefore, it can be concluded that incorporation of spray dried spirulina powder into a diabetic diet would play a useful role in the management of hyperglycemia and hyperlipidemia.

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